

A New Generation of Fusion Imaging: iFusion with Respiration Compensation

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Background of Fusion Imaging

Diagnosis and interventional therapy by ultrasound (US)-guided hepatic angiography are a key clinical technique starting from scratch and rapidly developing in recent decades. Compared with CT/MR, ultrasound-guided angiography and intervention are characterized by good real-time performance, low cost and no radiation. But it is difficult to obtain definite images by routine ultrasonography or even angiography and to achieve effective guided interventional treatments because some lesions are small in size, deep or interfered by gas.

As a breakthrough technology, fusion imaging can combine the advantages of CT/MR and ultrasonography, as Fig.1 shows. Like car GPS navigation system, 3D image data of CT/MR collected previously has been imported into ultrasonography system, which is equal to the map in GPS system. Real-time ultrasound

image is similar to sight of human eyes. Fusion imaging system can extract two-dimensional CT/MR image, which is in accordance with present ultrasonic scanning section, in the 3D data of CT/MR in real-time. After matching with real-time ultrasonic image exactly, the images can be compared, fused, overlapped and demonstrated. With the help of high-resolution image information from CT/MR and real-time advantages of ultrasound, real-time fusion navigation can help users locate lesions more accurately. Diagnosis and treatment with the help of fusion imaging can improve not only users' confidence in diagnosis of intractable liver diseases, but also increase the accuracy of positioning ultrasound-guided interventional therapy in the treatment of liver diseases, and help doctors assess accurately effects of interventional therapies in time.

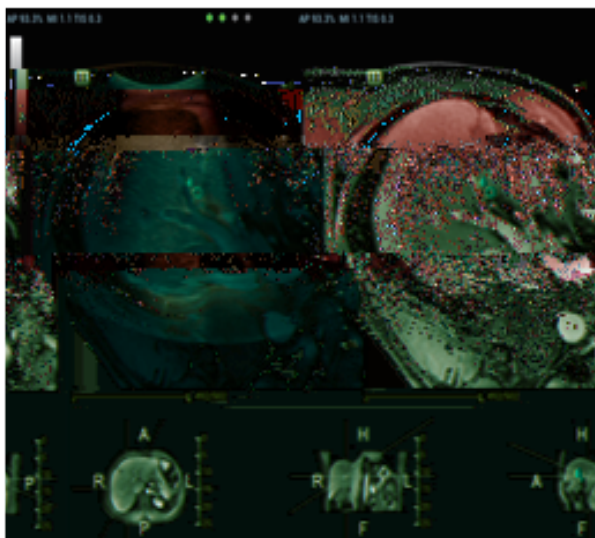


Fig.1 Fusion imaging with hepatic tiny lesion

Limitations on the Development of Fusion Imaging

But, the biggest challenge in clinical application of fusion imaging is the accuracy of image fusion. With static data collection of CT/MR in certain moment and real-time changes of ultrasound image, inevitable breathing movement of the patient is the major influence factor of the accuracy of fusion matching. The new generation Mindray iFusion with respiration compensation can improve the accuracy of fusion imaging to a new level.

Workflows of Routine Fusion Imaging

Generally, there are three basic operation steps of routine fusion imaging, including data import and tagging target marker, registration and fine tuning, real-time fusion navigation.

1) Data Import and Tagging Target Marker

Clinical Significance:

It is convenient to do fast and precise positioning of multiple target tissues during the fusion procedure.

Operation Method:

CT/MR data in DICOM format can be imported into the Fusion system in many ways, including USB disks, CDs or network servers, et al. The data imported can be browsed by users, and it can be visualized in any direction and at any arbitrary angle via MPR (multiple planes rendering).

Mindray's iFusion system can allow users, in the MPR display status, to tag multiple target markers in a spherical fashion on CT/MR images (Normally liver tumors are less than 3 cm in diameter, regular shape and close to sphere.). When tagging, just browse to the maximum radial section of the target tissue and determine its central point and radius by mouse clicking and trackball movement. Meanwhile, target markers can be mapped to fusion image automatically, as shown in the circle in Fig.2. During the procedure of fusion navigation, when the user rescans these targets from different angles, target markers with corresponding colors and serial numbers can be displayed on present section in real time.

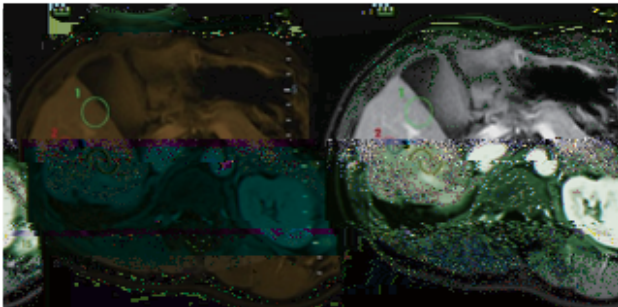


Fig.2 Target markers

Registration and Fine Tuning

Clinical Significance:

Establish an accurate corresponding relationship between ultrasound and CT/MR images, in order to obtain high precision of fusion imaging.

Operation Method:

iFusion achieves registration in a single plane manner manually. Search the same section in ultrasound and CT/MR, then move the images of CT/MR, so that, the images can be matched, overlapped and demonstrated. Users can either select CT/MR

section first, then find corresponding ultrasonic section by probe, or search corresponding CT/MR images after collecting and determining ultrasonic section. It is suggested that initial registration is usually conducted on the scanning plane of the left portal vein's sagittal part.

In clinical applications, the precise registration is usually carried out in two steps: initial registration and fine tuning. Also in a single plane manner manually, fine tuning generally selects a different section from initial registration, in order to achieve the result of multi-dimensional precise matching. During fusion navigation, fine tuning may be carried out at any time if decreased fusion accuracy is found for some reasons such as patient motion.

2) Real-time Fusion Navigation

Clinical Significance:

With the help of CT/MR image and target markers, fusion navigation can help sonographers to make the diagnosis and treatment more precisely.

Operation Method:

When the registration is completed and confirmed, real-time fusion navigation mode can be entered. Mindray's iFusion supports the ultrasound not only in conventional B-mode, but also Color/Power and CEUS modes. With the help of precise positioning of lesions by iFusion, the combination between CEUS and fusion can further provide more information on blood flow's dynamic perfusion, leading to improved diagnostic confidence of intractable liver diseases and also accurate assessment of interventional therapies. Mindray's iFusion also supports CEUS with dual modes (Fig.3), which can at the same time display ultrasound tissue images, fused images of ultrasound tissue and CT/MRI, CEUS images, and fused images of CEUS and CT/MRI. So it allows users to observe lesions in different types of imaging modes more conveniently, providing more clinical information.

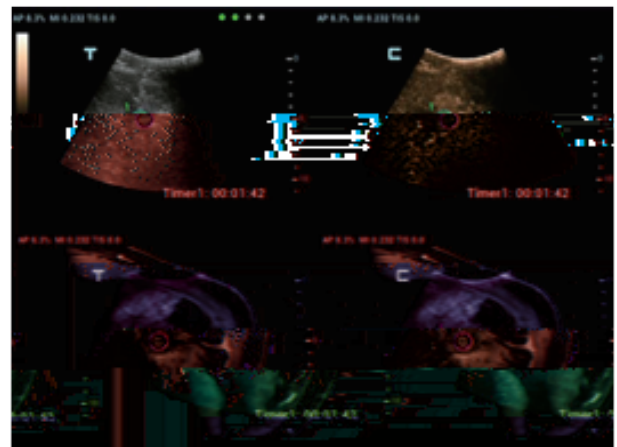


Fig.3 iFusion with CEUS in dual mode

Mindray's iFusion also supports CEUS with dual modes(Fig.3), which can at the same time display ultrasound tissue images, fused images of ultrasound tissue and CT/MRI, CEUS images, and fused images of CEUS and CT/MRI. So it allows users to observe lesions in different types of imaging modes more conveniently, providing more clinical information.

Work flows of the New Generation iFusion with Respiration Compensation

Clinical Significance:

Compensation of respiration-induced fusion errors can improve the accuracy of fusion imaging to a new level and improve the precision of interventional diagnoses and treatments.

Principle of Respiration Compensation:

Generally speaking, CT/MR data is the static data collected in a certain fixed respiration phase, while real-time ultrasound images change in real time with the periodic change of patient's respiration phases. Because of patient's inevitable respiration, although two kinds of images can be registered accurately at the registration moment, there are still unavoidable patient's respiration-induced errors during the entire procedure of real-time fusion navigation.



Fig.4 A new generation of iFusion with respiration compensation scenario

Based on the motion sensor with the accuracy of millimeter level(the motion sensor is attached to the belly as shown in Fig.4), Mindray's innovative and patented technology of respiratory compensation can remedy the respiration-induced fusion and matching errors greatly, so that, it can improve vastly the accuracy of fusion imaging and confidence in diagnosis, intervention and treatment.

Compared with routine fusion imaging procedure, the new generation iFusion with respiration compensation just needs to add one more step before fusion navigation step: respiration modeling, as shown in Fig.5. The core technology includes respiration gating, respiration modeling and respiration compensation.

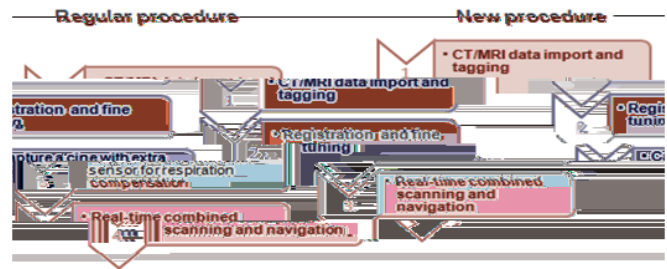


Fig.5 Fusion imaging procedure

1) Respiration Gating

By means of the motion sensor attached to the belly, iFusion can monitor the current phase of respiration in real time and record the phase of respiration during registration. (As is shown in Fig.6, the abscissa represents time and the ordinate represents changes in respiration phase which is reflected by displacement of motion sensor.) The green curve represents the change of real-time respiration phases, the red shot line represents corresponding moment of current selected frame, and the blue horizontal line represents respiration phase at the registration moment. The bigger the difference in respiration phases between present moment and registration moment, the bigger the fusion errors are. As shown by the clinical research, the respiration-induced liver fusion error may be up to more than 1 cm. Based on above information, sonographers can observe the phase difference between the present moment and registration moment, so that they can ensure the credibility of present fusion effectively. This is respiration gating. Meanwhile, respiration gating can provide useful information for subsequent respiration modeling and compensation.

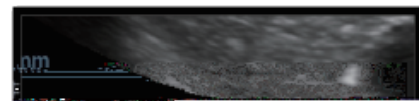


Fig.6 Respiration Gating

2) Respiration Modeling

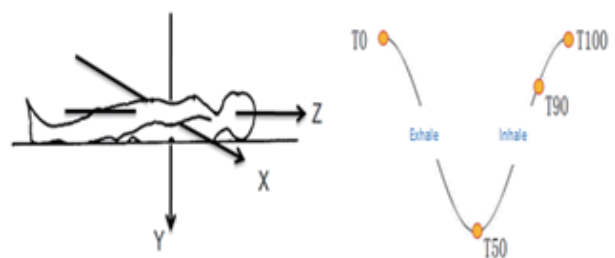


Fig.7 Human body coordinates and respiration phase curve

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